MOLECULES PRODUCED ON THE SURFACE OF EUROPA BY ION IMPLANTATION IN WATER ICE. O. Gomis[1], M. A. Satorre[1], G. Leto[2] and G. Strazzulla[2], [1]Dpto. de Física Aplicada, Escuela Politécnica Superior de Alcoy (UPV), Placeta Ferrándiz Carbonell 2, 03801 Alcoy (Spain); osgohi@fis.upv.es, msatorre@fis.upv.es, [2]INAF-Osservatorio Astrofisico, via S. Sofia 78, I-95123 Catania, Italy; gle@ct.astro.it, gianni@ct.astro.it.

Abstract: Europa surface spectra reveal that its main constituents are in the form of ices. Between them frost H_2O [1] is dominant although traces of CO_2 [2], SO_2 [3][4], O_2 [5] and H_2O_2 [6] have also been found. Other compounds found mainly in the darker regions are hydrated materials [7][8]. Europa is located inside the intense magnetosphere of the giant Jupiter. The magnetosphere is populated by protons and ions such as S^{n+} and O^{n+}, and energetic electrons [9]. In fact, one of the mechanisms suggested to be responsible for the formation of the icy molecules present on Europa is the interaction of the magnetospheric plasma with the surface of the satellite. When an energetic ion collides with the icy surface, part of the deposited energy destroys molecular bonds in the target producing radicals that can then react to synthesize new molecules. In the case of a thick satellite surface, in which ions are implanted, the possibility exists that the new produced molecules contain the incident ion [10].

We have carried out implantation experiments of ions relevant to the Jovian system in water ice and mixtures. We focused on studying and characterizing the molecules formed by ion implantation and to analyze if this mechanism can quantitatively account for some of the species found on the surface of the satellite. Also of our interest is the study of likely chemical pathways that could give rise to the new molecules. The used experimental technique has been in-situ infrared spectroscopy. Our results are also relevant to other Galilean satellites and to other places inside the Solar System.

In this work we present the results of experiments of ion implantation in pure water ice by using five different types of ions (H^+, C^+, N^+, O^+ and Ar^+). We have first focused on the study of the production of the hydrogen peroxide molecule. The energy of the used ions is 30 keV and the experiments have been carried out at 16 and 77 K. Our experiments show that H_2O_2 is produced at both temperatures and by all the different ions. We have found that the quantity of produced H_2O_2 is greater for ions with a higher stopping power, being protons the ions that produce the smallest quantity [11]. We have also observed that oxygen is the ion that at 77 K produces the greatest quantity of H_2O_2. More precisely, an asymptotic value of about 4% of H_2O_2 (into respect to H_2O) in number of molecules has been found for O^+ implantation. Because this value of H_2O_2 concentration is much greater than the 0.13% inferred by the NIMS feature on Europa, we suggest that hydrogen peroxide could be, on the surface of the satellite, distributed only in patches. This result could be useful to support the suggested possibility of a radiation-driven ecosystem on Europa based on the availability of organic molecules and oxidants such as hydrogen peroxide. Also of great interest is the possibility that the H_2O_2 could reach the putative subsurface ocean [12].

We have also found that C implantation into water ice produces CO_2; the production yield (molec ion^{-1}) has been measured [13]. For the case of Europa a better estimation of the C^{n+} ion fluxes that impinge on the satellite is needed in order to estimate if carbon implantation could be in fact responsible for the quantity of CO_2 found on the satellite.

Future planned experiments are the implantation of sulfur ions into water ice to study the production of SO_2 and sulfates. Sulfur implantation has been in fact suggested to be responsible for the formation of SO_2 found on the surface of Europa [3][8][14].

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